

E=mc² and Other Artistic Equations: Encouraging the Complementary Skills of Einstein and of Picasso through Redefinition

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Abstract

C.P. Snow calls for communication between the “two cultures” of arts and humanities and science and mathematics so that, globally, humanity can survive and prosper. This paper suggests that when individuals begin to identify with both “cultures,” they will be less tolerant of such polarity within education and society and will begin to foster and even expect a mending of this fractured societal persona. My thesis comes from the results of a questionnaire answered by 55 of my students—members of the “science and mathematics culture,” for they attend a science, engineering, and technology research institution. The results of this survey strongly suggest that teaching non-dualism, non-oppositional or complementary dualism—meaning differences that work together for a whole, such as illustrated by the yin yang symbol—is validating for many students.

Survey results also show that most students feel that the scientific and artistic aspects within their personalities are balanced or close to balanced; many answers suggest that students are seeking a resolution of this breach in their education and in society. Some surprising results emerged from the survey, such as revealing that an almost equal number of students considered themselves “predominantly artistic” as do those who consider themselves “predominantly scientific.” Results also articulate further redefinition is needed in each of the “two cultures” for their equal validity in society. Specifically, most likely from educational and societal training that begins when young, students do not recognize the transformative value of the socio-political impact of art and do not understand that artists are often technicians of social change.

E=mc² and Other Artistic Equations

In his 1963 essay “The Two Cultures: A Second Look,” C.P. Snow calls for communication between what he describes as the “two cultures” of “scientists” and “literary intellectuals” (Snow, 1963, p.59) so that, globally, humanity can survive and prosper (Snow, 1963, p.59, p.64, p.68, p.90). In fact, in this follow up essay to his “The Two Cultures and the Scientific Revolution,” 1959, Snow stresses the direness of the polarized situation between the “two cultures.” He emphasizes the necessity of fostering communication, the dangers of this polarization to life on a global scale as, Snow states, “...science is determining much of our destiny, that is whether we live or die,” and the imperative responsibility of educators to ensure communication that will hopefully be regarded by political “decision-makers,” for, he adds, “...the purposes of avoiding disasters, or for fulfilling—what is waiting as a challenge to our conscience and goodwill—a definable social hope” (Snow, 1963, p.90, p.91).

It may be possible—through redefinition—to achieve some steps toward this “definable social hope” by helping students and educators to see or by validating what many already see: that the “two cultures” exist within each person and that recognizing these different aspects of ourselves as complementary rather than in opposition contributes to a balanced, healthy, and whole personality. I suggest that when individuals begin to identify with both “cultures” they will be less tolerant of such polarity within education and society and will begin to foster and

even expect a mending of this fractured societal persona. My thesis comes from the results of a questionnaire answered by 55 of my students¹—members of the science and mathematics “culture,” for they attend a science, engineering, and technology research institution, New Mexico Institute of Mining and Technology—who were taking one² of the following three Humanities courses during the Spring semester 2006: Art History 372, Modern Art; English 311, Creative Writing; and Technical Communication 211, Rhetoric and Media.

Using redefinition in the classroom. Before discussing how I have interpreted the results of the survey, I will explain how I have used redefinition in the classroom. I believe and teach—to varying degrees, according to the course³—that articulated and supposed differences are not in opposition but are complementary and, thus, necessary for a healthy and whole personality and society. I offer alternative philosophical ideas, whether called monism, unity, pluralism, non-dualism, non-oppositional dualism, or complementary dualism,⁴ rather than perpetuating the predominant dualistic philosophy of western culture that defines differences as opposites and, thus, as in opposition—one being good or right and the other being bad or wrong—and forever divided. Further, my method of redefinition includes my theory that personalities are either form-driven or content-driven and that individuals, though driven by their dominant skills, need balance in these traits. Specifically, a person’s life choices, i.e. education and career, are chosen

¹ 54 different students; one student was in two courses. There are a total of 55 answered questionnaires. I may use “students,” “majors,” “answers” and “respondents” or other wording interchangeably.

² Again, one student was taking two courses and answered a questionnaire in each course.

³ During the semester, such discussions occurred at different times in Modern Art. This discussion was just one class meeting in Rhetoric and Media, though that course did discuss preferred readings by the power structure and the influence of visual and verbal rhetoric on society and individuals. As well, the form-driven/content-driven discussion was during only one class period in Creative Writing, though essential to this course was the identification of the themes of works of short fiction, creative nonfiction and poetry that is based on the human condition and the subsequent creation of such themes in student writing. Also essential to this course was literary analysis of readings and of their own creative writing; thus, the course required students to be analytical and to be able to identify and to create formal elements as well as be able to be imaginative, to write creatively, and to try to create literary art. For Rhetoric and Media and for Creative Writing, I had this discussion in class mostly to gain information for this research, though in past courses, I usually have the discussion at some point, even if it is only a one class period discussion.

⁴ I actually had not yet used the terms complementary dualism, non-oppositional dualism, oppositional dualism, or non-dualism as such in my teaching when doing this research, but I am now doing so. In thinking about this paper, I thought of the terms complementary dualism and non-oppositional dualism. Upon researching these terms, I have found they are fairly widely used. In my courses, I have discussed the same concepts, but without such appropriate terminology. I did use descriptions about the dualist aspects being complementary rather than oppositional without actually calling the idea or philosophy complementary dualism or non-oppositional dualism. Typically, I referred to the idea as monist, different parts that completed a unity or whole and that, ultimately, the differences must work together for an overarching good. For subsequent instruction, I plan to use the terms complementary dualism and non-oppositional dualism.

by that person's preference for that which is form-driven, meaning life situations where form, formulas or structures are primary and the content results from that form, or content-driven, meaning life situations where imagination and experiences are primary and the form or structure results from those experiences. Thus, those with the propensity for the studies of science and mathematics tend to be form-driven, while those with the propensity for the studies of arts and humanities tend to be content-driven.

For example, Albert Einstein could be seen as having had a form-driven personality that tends to favor reason, logic, method, and formulas; however, he must also have had significant content-driven traits that enabled him to value and exercise the imaginative qualities required by invention. I suggest that his idea of 1905, $E=mc^2$, is an artistic equation. This equation and the possibilities of its suggestion have led to a whole universe of imaginative, yet scientific, thinking. Explaining the equation, Bill Bryson writes, "In simplest terms, what the equation says is that mass and energy have an equivalence. They are two forms of the same thing: energy is liberated matter; matter is energy waiting to happen" (Bryson, 2003, pp. 121-122).⁵

Ideas are the result of creative thinking; applied to science, they are then often referred to as inventive thinking. In his special theory and his general theory, Einstein used what I would call a balance of content-driven traits—ideas, imagination, and invention—with the form-driven traits of structured, methodical, formulaic thinking. Essential to moving science forward, ideas may come as flashes of insight only on occasion. Bryson relates the following about Einstein's ideas, "When the poet Paul Valéry once asked Einstein if he kept a notebook to record his ideas, Einstein looked at him with mild but genuine surprise. 'Oh, that's not necessary,' he replied. 'It's so seldom I have one.' I need hardly point out that when he did get one it tended to be good" (Bryson, 2003, pp.123-124). It is hard to imagine how we would perceive our world today without Einstein's two "good" ideas.

Pablo Picasso, a highly content-driven person who continually favored the experiential, lived his artistic life in constant liberation from a firm basis in the formal aspects of his form-driven artistic training, which he had mastered by age 14 or 15, as is shown in his painting *First Communion*, 1895/96. He might have developed some of this ability through an interest in another form-driven study, that of mathematics...however, not actually in the equations, but in the shapes of the numbers. Ingo F. Walther writes, "Later in his life, Picasso used to tell that he

⁵ This equation fits well with the idea of complementary dualism.

had really only been interested in the way the teacher wrote the numbers on the blackboard. He would copy their shapes, but had absolutely no interest in the mathematical problem. He often wondered how he had ever managed to learn basic arithmetic" (Walther, 1993, p.8). By age 15, his form-driven skill resulted in the technically precise *First Communion*, 1895/96, which was exhibited "at what was then the most important exhibition ever held in Barcelona," Walther states (Walther, 1993, p.10). His ability to copy numbers from a chalkboard would grow to, at age 16, copying the masters at the Prado (Walther, 1993, p.10). Walther writes, "At first he copied the old masters and tried to imitate their style; but later they were to serve as themes that would give him fresh ideas for original paintings of his own, and he would re-arrange them again and again in different variations" (Walther, 1993, p.10). By 1899 he was befriending modernist painters in Barcelona, would begin leaving his form-driven work behind, and would soon leave for Paris, where he experienced, Walther says, "freedom from conventions and traditions" and "where he found the necessary openness for his artistic experiments" (Walther, 1993, p.10, p.12).

This change in his art from a traditional, classical, form-driven approach to his unconventional, modernist, content-driven approach affected his relationship with his parents who could not, Walther states, "understand either their son's Bohemian attitudes or the lack of control in his art" (Walther, 1993, p.12). His "Bohemian attitudes" and "lack of control in his art" were due to the dominant content-driven personality aspects that would pave the way for his artistic lifetime of new ideas. However, the established formal aspects to his talents attest to a personality that, while driven by imagination, experience and free expression, is balanced with a methodical, logical side.

However, I do not contend that artists must be content-driven and that scientists must be form-driven. In fact, I would claim form-driven artists include Piet Mondrian and Josef Albers, and that Charles Darwin may have been a content-driven scientist. And some may argue that Einstein was a content-driven scientist. Again, my theory is that one aspect of our personality drives us, but that a balanced, healthy, whole and functioning person needs to be balanced in aspects of both the form-driven and content-driven personalities. A symbol for this is the yin yang symbol.

Though a symbol for dualism, yin yang illustrates how each half completes the whole; thus, it recognizes differences, but that these differences work together for a balanced, whole image. The circle can symbolize an individual and the necessary divided yet united aspects of a

personality; it can also symbolize this need in society between the “two cultures” of science and mathematics and arts and humanities. An equation for this same philosophy can be Einstein’s $E = mc^2$, as it scientifically/mathematically describes, in Bryson’s earlier-stated words, “two forms of the same thing.”

Discovering how science and mathematics students perceive “scientific and artistic” personality traits and cultures. To discover science, engineering, technology, and mathematics students’/majors’⁶ responses to seeing the form-driven and content-driven aspects of themselves and of their perception of their culture of science and mathematics and of the “other culture” of arts and humanities, I developed a 19-question survey that focused on two main terms: scientific and artistic. I wanted to learn how science and mathematics students perceived these terms as personality traits and as traits of separate “cultures.” I did not give them instruction about C.P. Snow and his articulation of the “two cultures.”⁷ However, as stated earlier, I did, to differing degrees according to the course, give some instruction on form-driven and content-driven personalities and on the ideas involved with complementary or non-oppositional dualism.

I chose an open-ended survey in the hope that students, even with questions that offered a choice or a yes or no for the answer, would write comments, which they did. In fact, student

⁶ *The Technical Communication major is actually a Humanities major, the only Humanities major at New Mexico Institute of Mining and Technology (New Mexico Tech). However, it is a B.S. degree and requires “12 credit hours in a single discipline [of science or engineering] in excess of general degree requirements” (*New Mexico Tech Course Catalog, 2006-2007* (2006) New Mexico Institute of Mining and Technology, p. 89).

**Mathematics offers a B.S. in Mathematics with “eight sub-fields of mathematics” (*New Mexico Tech Course Catalog, 2006-2007* (2006) New Mexico Institute of Mining and Technology, p. 105). One student’s answers showed that some sub-fields of mathematics might not be considered scientific; other student answers seemed to also suggest this.

***General Studies is the only degree at New Mexico Tech at that does not have science or mathematics requirements, is offered as an Associate of General Studies or a Bachelor of General Studies, and, according to the catalog, “is not recommended as an initial degree program, but does provide an option for students not intending to seek graduate training or professional employment” (*New Mexico Tech Course Catalog, 2006-2007* (2006) New Mexico Institute of Mining and Technology, p.88).

⁷ However, the Informed Consent form did state the following as its purpose:

“To discover responses from science and mathematics students who are taking

arts and humanities courses to seeing the form-driven and content-driven aspects of themselves and of others and how this redefinition, articulated in the classroom, affects their perception of their culture of science and mathematics and of the ‘other’ culture of arts and humanities. This information will be used in a presentation at The Oxford Round Table, July 9 – 14, 2006, Oxford, England and may be used in articles and/or books for publication and in additional presentations. The Oxford Round Table session is *The Two Cultures: The Current Debate*, a forum discussing the state of the relationship between the two ‘cultures’ of science and mathematics and arts and humanities.”

The survey sheet stated: “Thank you for answering these questions and agreeing to be a part of this study. This information will be used in a presentation at the Oxford Round Table, July 9-14, 2006, Oxford, England and may be used in articles and/or books for publication and in additional presentations. The Oxford Round Table session is *The Two Cultures: The Current Debate*.”

responsiveness is telling: when only a one word answer was required, in most cases and for almost all answers, students chose to write developed answers and to make comments, suggesting that they wanted to express their viewpoints on this issue. The consideration students gave to each answer and their diligence in answering the 19 questions attest to their invested interests concerning their beliefs, their education, their personalities, and their society concerning the “two cultures” and has provided valuable information for suggestions for educators made by this study. These comments offer significant information that a mere yes or no or choice answer would not provide. The information from the extensive number of comments as a whole is, I feel, as revealing as or more revealing than the quantification of the answers. Also, the intensity of word choice and overall manner of how students answered is also revealing. In this paper, I have provided selected student comments; however, I derived my interpretation from thorough review of all student answers. While this is a qualitative survey and the written comments provide information that mere numbers do not give, I believe quantifying the information from the responses is essential. Quantifying written answers is difficult as wording varies; thus, I have checked and re-checked these answers. However, another reader may interpret an answer somewhat differently than I have. Thus, there is a chance of marginal discrepancy in numbers.

The results of this survey strongly suggest that teaching non-dualism, non-oppositional, or complementary dualism—meaning differences that work together for a whole,⁸ such as illustrated by the yin yang symbol—is validating for many students. Survey results also show that most students feel that the scientific and artistic aspects within their personalities are balanced or close to balanced; many answers suggest that students are seeking a resolution of this separation of talents in their education and in society. Results also articulate further redefinition is needed in each of the “two cultures” for their equal validity in society. Specifically, most likely from educational and societal training—or lack of training—that begins when they are young, students do not recognize the transformative value of and socio-political impact of art and do not understand that artists are often technicians of social change.

Following are the 19 questions (or groups of questions). After each question, I have interpreted the results of the survey, and then I have included selected student comments. Again, student dedication to answering these questions is commendable, and I have chosen to reproduce their answers as accurately as possible, though it is hard to do some in some cases, as they may

⁸ See note 4.

have made notes in margins, etc. However, I have tried to keep the spelling and grammar as it was written, and thus, have not grammatically corrected the comments. I have chosen to use [sic] after grammar and spelling errors. Because punctuation errors are fairly numerous and using [sic] after each would be, I feel, disruptive to the reader in gaining the content of the answers, I have put the correct punctuation mark in brackets after the punctuation or lack of punctuation, used by the student rather than [sic]. In this study, I feel it is the content of the answers that is important. It is not my intention to highlight spelling or grammatical errors, and this, I feel, should not be an aspect of this study. They answered the questions in about 45 minutes or less, which was little time to so thoroughly and thoughtfully answer so many questions, and having such limited time might have, thus, affected their grammar, punctuation and spelling. In addition, for clarity, I have underlined the categories of the answers. The wording of these categories might not be the words that the students used but are rather general wording I have chosen in an effort to group the answers. In addition, I highlighted some ideas or findings by underlining or italicizing. Questions, interpretation, and selected student comments follow:

1. *What is your major?* Single Majors: Mechanical Engineering; Biology; Technical Communication; Chemical Engineering; Physics/Astrophysics⁹; Electrical Engineering; Computer Science; Information Technology; Mathematics; Petroleum Engineering; Chemistry; General Studies; Psychology; Civil Engineering; Management.

Double Majors: Technical Communication and Management; Technical Communication and Mechanical Engineering; Chemistry and Biology; Physics and Mathematics; Mathematics and Chemical Engineering.

2. *Do you consider yourself predominantly scientific or artistic?* Interestingly—and what I would not have predicted—21 students stated they feel that they are predominantly artistic in comparison to an almost equal number—23 students—who stated they feel they are predominantly scientific. Another 6 stated they are both scientific and artistic or related wording; 3 stated both but more scientific or related wording, and one student stated both but more artistic or related wording. One student, a Mathematics major, stated, “I consider myself predominantly mathematical (not scientific and artistic)[.]” Thus, just over half of the 55

⁹ One of the Physics majors listed Astrophysics as his or her major. However, the actual major is “Physics with Astrophysics Option,” according to the *New Mexico Tech Course Catalog 2006-2007*, 112. I will refer to this student as a Physics major.

respondents—a total of 28—feel they are either predominantly artistic or both scientific and artistic or both but more artistic. Thirty-two (32) respondents feel they are either predominantly scientific or both scientific and artistic or both but more scientific.

In answer, a Mechanical Engineering major wrote: “Artistic in nature, scientific in practice, I think like an artist but act like a scientist[.]” A Technical Communication major answered: “Artistie. Wait...scientific. Both. Can’t pick one.” A Biology major commented, “More artistic, yet I try to find creativity in science.” And a Physics major stated: “Both[.] I see science as an art & I have been accused of treating my art scientifically[.]”

3. *If you answered scientific, do you see artistic aspects to yourself?* All respondents except one who answered that they were predominantly scientific or both scientific and artistic or both but more scientific—31 students—said they saw artistic aspects in themselves.

An Information Technology major answered: “Yes, there is a lot of creative process that goes into my daily work[.]” A Physics major wrote: “Yes. I play/write music. Science is art for me[.]” Another major commented: “Yes. I grew up with viewing plays, dance classes, and opera. I chose science over art for money purposes.”

4. *Do you consider this a good and essential aspect to your personality?* Of the 31 who saw artistic aspects in themselves, 30 of these stated they consider this a good and essential aspect to their personality; one (1) stated good but not essential.

A Physics major wrote: “Yes, because its [sic] kept my mind more open to new ideas and clashing views than people around me, and helped me become more creative in my scientific path.” Another Physics major stated: “Yes, science without art is useless[.]” Another major commented: “This is definitely an essential aspect. Science gives me the tools to create things with my artistic talents.” And a Petroleum Engineering major wrote: “Yes, I find myself able to talk with anyone because I consider myself a well rounded person.”

5. *If you answered artistic, do you see scientific aspects of yourself?* All 28 stated yes or definitely or a related answer. No one answered no.

In answer, a double major wrote: “Definitely! All of my creative energies are bound by rules, formulas, structure.” Another major stated: “Yes, science is part of art, just as art is part of science[.]” A Biology major commented: “Yes, but often use an artistic view to help remember

scientific things.” Another student wrote: “Yes, I think science is fascinating. I just find that my mind leans more towards the creative side of things; it’s what I like.”

6. *Do you consider this a good and essential aspect of your personality?* Of these, 26 said they did. One stated: “I don’t consider it essential, but it helps in having a better understanding of the world, both physical and mental.” Another stated, “Not really,[;] I would like to know the how it works part.” A Biology major stated: “Yes, because knowledge can only give you strength, and gives deeper respect for the world around you. *understanding a problem helps you fix it.” An Electrical Engineering major wrote: “Yes, I think having a well rounded personality is very important to my personal growth.” Another student stated: “I do, but I focus more on the artistic side[.]” A Mechanical Engineering major commented: “Yes, having both allows me to communicate and understand on different levels.” And another student wrote: “As for a [sic] the ‘working’ world it is very important (ie making money good job)[.]”

7. *How do you define scientific?* Based on a comprehensive evaluation of terms students used in their definitions for Question 7 and from my interpretation of their answers to the other questions, a composite definition of “scientific” can be: understanding the world to solve problems using logic and method. The words “discovery,” “creativity,” and “artistic” were used minimally in the definition of scientific, suggesting that the students do not readily consider discovery, creativity, and artistry as essential to defining “scientific.”¹⁰ However, in subsequent answers, many stated the need for creativity in science or the belief that science does or even must involve creativity or art.

In defining “scientific” one major wrote: “Scientific, is using math, psychology, physics or engineering to solve and answer problems in society.” A Biology major wrote: “Something that

¹⁰ The following two questions ask for definitions. For this study, I needed to find a way to quantify the answers. Thus, the list below shows the words or related words used and how many times they appeared in the answers. There is room for marginal discrepancy in counting.

Question 7: *How do you define scientific?* Questioning, exploring, understanding, defining the world 15; Logic 14; Solving problems, approach to problems, answers 9; Method 8; Analytic 7; Rational, reason 7; Facts 5; Formula, rules, formal 4; Experiment 4; Structure, order 3; Pattern 3; Process 2; Skeptical 2; Does not allow new thinking 2; Discovery 2; Technical 1; Proof 1; Objective 1; Organization 1; Observation 1; Evaluate 1; Persevere 1; Artistic 1; Curious 1; Creative reasoning 1; Changes in ideas 1; Constantly questioning 1; Creation of new technology 1; Requires creativity 1.

Question 8: *How do you define artistic?* Creative, imagination, inventive, originality 27; Emotion, feeling 14; Free (or related), challenge beliefs, exploring, open-minded, unique 11; Aesthetic, beauty 9; Experience, interpret world 6; Expression 6; Approach to problems, solve problems, beneficial to life/society 6; Personal experience 4; Soul 4; Human condition, understanding humanity 2; “Analysis of the nature of emotion” 1; Passionate 1; Intuitive 1; Patterns 1; Devoid of logic 1; Chaos 1; Logical reasoning 1.

involves research and the creation of new technology and theories that allow us to live more efficiently...it's about discovery." And another major wrote: "Being scientific requires an education and effort. It is being able to logically solve problems."

8. *How do you define artistic?* Based on a comprehensive evaluation of terms students used in their definitions for Question 8 *and from my interpretation of their answers to the other questions*, a composite definition of "artistic" can be: being creative or free to express emotion or beauty or possibly to challenge beliefs. Solving problems and expressing the human condition or addressing social issues can be involved but are not essential to the definition, nor is rationality, nor logic, nor method.¹¹ Additional answers seem to emphasize the emotional, aesthetic and even recreational aspects of art over its social value or its ability to challenge beliefs or to help the world.

For example, the same student mentioned in the above answer who stated "Being scientific requires an education and effort" defined artistic as: "Being artistic also takes effort. However[,] to me it seems to be sort of a selfish trait if which [sic] you are to[sic] obsessed with your own emotions." A Biology major stated: "Something that soothes the psyche. An area that helps revamp your soul and make the world beautiful." Another Biology major stated: "I define artistic as being more concerned with higher ideas like beauty than with the hard facts." A Technical Communication major answered: "Artistic to me is anything that is created solely for its asthetic [sic] value, and may not be connected to math, science, etc." In answering if, being predominantly scientific, having artistic aspects is "good and essential" to one's personality,¹² a Biology major stated: "Yes...Science is very fast-paced - - art is a good way to relax." Another major wrote: "Good, yes, essential, no. I could try getting by without art, but that would be like an unfrosted cake, dry and boring." A Mechanical Engineering major stated: "Yes, it is like the icing [sic] on the cake, makes life sweeter[.]" Commenting on a different question,¹³ a Mechanical Engineering major wrote: "Artistic aspects tend to deal [sic] social/personal workings: trends, behavior, emotion. They seem to be attached to 'non-essential' things that move towards a more 'cultured' person or group."

¹¹ See above note.

¹² In answer to Question 4, which is a second part to Question 3.

¹³ In answer to Question 16.

9. *Do you see scientific and artistic aspects as opposing or complementary aspects of a personality?* Most respondents, 40 to 46 of the 55, described scientific and artistic aspects of a personality as complementary or related wording.¹⁴

A Mechanical Engineering major answered: “They’re definitely complementary. Engineering could not exist if they weren’t[.]” However, another Mechanical Engineering major stated: “I find them opposing. When confronted with an engineering problem there is no choice over what aspect to use,[;] it has to be scientific.” A Biology major commented: “My scientific aspects control my artistic but also provide my artistic aspects an avenue of expression[.]” A Chemical Engineering major wrote: “Complementary. From a more scientific point of view, I see my artistic side as what gives me the creativity to solve many of the complex problem [sic] that I encounter in engineering. And all good chemist [sic] know that ‘chemistry is an art form[.]’” And an Electrical Engineering major explained: “When I see a person who claims to be artistic standing next to someone who says they are scientific, there are a lot of opposing images between the two. But for me, individually, I couldn’t live without both aspects in my personality.”

10. *Do you see the scientific “culture” and artistic “culture” as opposing or complementary aspects of society?* While 14 to 20 students see the “two cultures” as complementary or related wording, at least half—approximately 27 to 32 students¹⁵—see the scientific “culture” and the artistic “culture” as opposing aspects of society or related wording, though 9 stated they do not agree with this cultural training.

One student stated that the cultures are: “Opposing as of this moment. I think my generation may change this. I believe most of my fellow scientific students embrace artistic ability.” Another student wrote: “Sadly, I see it as opposing. However, I would love to see society embrace both as necessary interconnected parts of the whole.” Someone else commented: “The cultures seem to be opposing because each neglect the importance of the other.” Another major stated: “They seem to oppose each other in society on the whole. Most

¹⁴ In answer, 40 students stated complementary or related terminology; 6 stated that the scientific and artistic aspects of a personality were closely related or dependant (or used related wording) or that these aspects were both opposing and complementary in a personality.

¹⁵ This is a total of 24 who believe the “cultures” are opposing, 3 who stated variations of opposing, and 5 who stated or suggested that the “cultures” seemed to be both opposing and complementary. This is in comparison to 14 who see them as complementary or related wording, one (1) who stated a variation of complementary, and the 5 who wrote wording that implies both complementary and opposing. However, these answers are difficult to quantify, and these numbers could be open to marginal discrepancy.

scientific people don't really seem to appreciate art as much as science and vice-versa." Another respondent wrote: "It seems like it used to be much more complementary than it is today (DaVinci, for instance, illustrated this beautifully)[.]" A Chemical Engineering major stated: "Although they should not be, I do see them as opposing one another." And another student commented: "They do seem to clash, but that's [sic] because scientists and artists are usually both very stubborn."

11. *Do you feel both "cultures" are equally important for a healthy, whole, balanced, functioning society?* Nearly all respondents, 47 of the 55, stated that both "cultures" are equally important for a healthy, whole, balanced, functioning society; 5 stated no or a related answer, and 3 stated answers I categorized as "other." However, many answers still are inclined toward science as being necessary for health and life, while art is important in more philosophical or emotional ways.

For example, in answer to this question, an Electrical Engineering major stated: "Absolutely, without science there aren't the advances we have in medicine and technology, and art helps us remember our human and spiritual selves." A Biology major wrote: "I feel that both cultures are definitely needed. Art is good for the soul and science is necessary for progression." Another Biology major wrote: "Yes. Look how important both medicine and music are to our society..." Another major commented: "Both are very important. Science introduces concepts and ideas and artists look at society's response. Artists look at the effects of science." A Chemical Engineering major wrote: "No, I feel like the scientific is more important. Although both are important[,] Science is what give [sic] health and well being[.]" However, a Mechanical Engineering major wrote: "Definitely: The day people accept scientific progression with artistic hearts is the day the world is a better place." And another major commented: "Science is nothing without creativity. They need to be used together to improve and actually make society work." However, another student wrote: "No. (Society can not be healthy, whole and balanced.)"

12. *Do you think one "culture" is more important than the other?* Paradoxically, in a question that asks for the same information as Question 11, over a third—approximately 23¹⁶—stated or implied that one "culture" is more important, typically that of the scientific "culture."¹⁷ This

¹⁶ In answer, 15 students said yes or a related answer; 8 stated an answer that I categorized as "other" but was also a derivation of yes.

¹⁷ These two questions, Question 11 and Question 12, are worded differently but ask for the same information. How can one "culture" be more important if both "cultures" are considered equally important? However,

could be due to their articulated understanding of science as solving problems to help the world; whereas, their articulated understanding of art is that it is mostly about expressing emotion or beauty, and, while beneficial (especially to the emotions), is not necessary for life but makes life more interesting or fun, is seen as more recreational, and, as stated in Question 8 by one student, can even be viewed in some circumstances as “sort of a selfish trait.”

One student commented: “Technology is definitely important. I’d say more important on a global scheme than say music. So yes...but barely.” Another major stated: “I think beauty should be a little less important than function.” Someone else wrote: “Yes, science, because its [sic] proven to be the backbone of a culture and its research determines a culture’s future.” Another student stated: “Yes. Science. Science produces solutions while art displays emotion.” However, another major offered: “Artistic culture is the most important culture. I believe that without designing an idea from scratch, it is impossible to answer anything scientifically.” And another student commented: “No, each has their own aspects which are beneficial. Scientific progress contributes to a healthy (medically) society, wheras [sic] art contributes to an emotionally healthy society. Without one or the other society could be healthy/fulfilled but not both[.]” Another student commented: “One (Science) has a more prestigious place in a capitalist society.” And a Mechanical Engineering major stated: “In certain aspects of life. If one is chiefly dealing with medicine[,] I would say science is more important.”

13. *If someone said you were scientific, would you consider that a compliment?* Of the 55 respondents, 44 stated it would be a compliment to be called scientific.¹⁸

A Mechanical Engineering major wrote: “Yes, but not as much so as if they said artistic.” An Electrical Engineering major stated: “Yes, I am very proud of my scientific side. It’s almost as if saying I’m intellectually gifted,[;] at least that’s how it’s seen in most of the societies in America.” A Mathematics major stated: “Yes, as science takes a lot of work to achieve, while artistic talent is inherent.” Another student commented: “I would feel they were missing out on my thoughts and emotions, my desires.” And someone else wrote: “Yes & No. Yes because I am an engineer, but no because I am more than a scientist.” A double major stated: “I would be

approximately 23 students responded that one “culture” is more important, while 47, in Question 11, answered they are equally important. As there are 55 total respondents, this means several respondents contradicted their answers in 11 and 12 by claiming the cultures are equally important but that one culture is more important. Approximately 18 claimed the scientific culture is more important; 2 stated the artistic culture is more important; one (1) said in answer to question 12 that “The mathematical ‘culture’”...“is more important than” the scientific culture or the artistic culture.

¹⁸ Two stated no or related answers; 9 answered in a way that I categorize as “other.”

modest about it and take it as a compliment to my knowledge, but not my personality.” Another major commented: “Yes, but it would depend who was saying it. If an artist said this, I might be offended.” A Physics major stated: “Yes, because I think all people should be scientific in the way they approach life.” Another student stated: “I would think they might be a little confused—but happy they saw me as so smart.” And another student wrote: “Yes, though the term is nerd.”

14. *If someone said you were artistic, would you consider that a compliment?* Of the 55 respondents, 50 stated it would be a compliment to be called artistic.¹⁹ Interestingly, this is 6 more respondents than had stated it would be a compliment to be called scientific.

A Biology major commented: “Yes. I take pride in being able to create beautiful art that other people can appreciate.” A Physics major wrote: “Yes, because its [sic] telling me that I applied creativity to some form of my work.” Another major stated: “Yes, I don’t think it is bad to be an artistic person. I don’t hear that compliment at all because of my major.” An Electrical Engineering major wrote: “Not unless it was pertaining to my work in engineering.” And a Chemical Engineering major stated: “No, I would think they were saying I am not scientific.” A Mechanical Engineering major said: “Yes, I feel it is important to have the creative level of thinking and apply it to many different areas.” Another Mechanical Engineering major stated: “Sure, more so than scientific probably, but depends on the context.” And someone else stated: “Yes, unless the term was ‘hippie.’”

15. *Where do you think you developed your ideas about the scientific aspects of a personality or the scientific aspects of society? How do you think these ideas have been perpetuated?*

Several students gave multiple answers to this question; thus, the numbers will not total 55. I categorized the answers as follows: 33 answers were school and education or related answers. Fourteen (14) answers were growing up, experience, self, doing or related answers; 8 stated society, community, peers, friends or related answers; 6 stated home, parents, family or related answers, making a total of 28 answers of the non-academic and non-media categories. Nine (9) stated media, television, films or related answers.²⁰ Thus, school and education seem to have the most influence in developing and/or perpetuating one’s ideas about the scientific aspects of a personality or the scientific culture of society.

¹⁹ One (1) said no; 4 stated answers that I categorize as “other.”

²⁰ One (1) had no answer; there were 8 answers I categorized as “other.”

A Chemistry major wrote: "From my scientific experiences in the classrooms and labs. From my social groups & friends[.]" Another major stated: "They were developed in the classroom and perpetuated everywhere! Math and science are based on facts. You see the stereotypical 'smart' scientists with lab coats and calculators always solving problems." A double major wrote: "Well[,] society itself develops ideas for us. We simply are aware of the two cultures then decided which to belong to. The educational system is a main source of this development." And a Physics major related: "I learned by doing. All through grade school, this was the sense of science I got." However, a Chemical Engineering major related: "Growing up; I was always more interested in the substance of what surrounds us—not so much the asthetics [sic] about it. That is, when looking at a picture of, say, the planet Saturn, I always wondered what made the rings, not, for example, marveling at the planet's beauty."

16. *Where do you think you developed your ideas about the artistic aspects of a personality or the artistic culture of society? How do you think your ideas have been perpetuated?* Again, many students gave multiple answers. I categorized the answers as follows: while 22 stated school and education or related answers, a total of 54 answers were of the non-academic or non-media categories: 24 stated growing up, self, experience, doing or related answers; 15 stated home, parents, family or related answers, and 15 stated society, community, peers, social life or related answers. Only 4 stated media, television, and films or related answers. Thus, home, parents, family, community, peers, and self seem to be stronger influences than school and education or the media in one's understanding of the artistic aspects of a personality or the artistic culture of society, although student responses did include that taking art courses in school and actually creating art did help them to develop or appreciate their artistic selves. However, many responses suggest they had to seek art, whereas science—through school—was required.

For example, one student answered: "Through elective art courses and minimal 'aware' exposure in communities. Support for artistic culture has definitely increased the last 10 years (or maybe I'm just old enough to notice now)." Another student wrote: "Personally, I have always had an artistic mind[,] and I have always enjoyed art and appreciated people's creative abilities. These ideas have been developed in me each time I travel, visit a museum, or take an art class. At a Tech school, perpetuation of ideas about art are more self motivated. You have to want to take an art class or read about paintings[.]" The same Physics major mentioned in Question 15 answered how he or she learned about art: "Again, learning by doing, but with art it

was very much a more individual experience. I discovered this on my own. Society doesn't lend itself to art as much."

17. *Has taking this course and learning about monist philosophy, dualist philosophy, form-driven personalities and content-driven personalities changed your thinking about any of the above questions?*²¹ This question may have been answered differently if the wording had been "affected" your thinking rather than "changed" your thinking. As it is stated, however, answers reveal that *many students have been thinking about these ideas*. Several answers show that addressing these issues and teaching complementary dualism in the classroom does help students to identify with or does support feelings they already have about the desire for a complementary view of the scientific and artistic aspects of a personality and of society and does encourage them to embrace the complementary skills of Einstein and of Picasso. I believe this instruction is a positive step in fostering the communication between the "two cultures" called for by Snow more than 40 years ago.

In answer to the question, 23 of the 55 students answered in a way that was positive about course material as an influence to their thinking: 12 stated that the course material reinforced or influenced their thinking, made them more aware of concepts they knew something about, offered them reassurance or support or a similar answer ²²; 4 stated yes or a related answer; 5 stated somewhat or in some ways or a related answer; 2 gave answers I categorized as "other" but that were favorable in wording about course material. Other answers, for total of 55, were: 6 said no or a related answer, stating they already knew about these concepts or similar wording; 9 stated no or a related answer and offered comments; 16 stated no or a related answer, offering no comments; and one did not answer. In another way to interpret the answers, 23 respondents of the 55 expressed that they had already thought of or knew about these concepts, only some of whom are the same 23 who answered positively about the influence of course material, mentioned above.

In answer, a Mechanical Engineering major stated: "No, but It definately [sic] allowed me to see that I was going in the right path (spiritually/mentally). I guess this class was reassurance that I am not alone. (in thought process)." Another Mechanical Engineering major

²¹ See note 4.

²² Three (3) of these answers stated no or a related answer, that their thinking had not been changed but that it had been reinforced or similar wording.

wrote: “Not so much changed, just reinforced many ideas I already had.” A third Mechanical Engineering major wrote: “I certainly believe now that in order for society to work in harmony there must be a union between the two subjects, and a tearing down of the barriers between the two in order to allow for both to be present in all people.” (This answer was one I categorized as “other.”) A Technical Communication major wrote: “I don’t think it has changed my ideas, but it has certainly refined them.” A Computer Science major wrote: “Not too much,[;] it has reinforced what I felt.” A double major stated: “Yes, I realize that we live in a dualist society and that unless serious changes are made we will continue to stay that way. As far as the questions go, I already felt this way,[;] however, learning more about these philosophies [sic] only cemented the ideas.” A Chemical Engineering major said, “A bit, yes. It has provided the opportunity to study things that I have not had much exposure to[.]” Someone else wrote: “We only discussed the above for a brief period but yes it allows me to give a title to my personality.” Another respondent stated: “Yes, I definitely have the realization that the right/wrong absolute that we carry around should be questioned[.]” Another student wrote: “No, but it is interesting [sic] to think about content-driven mathematics [.]” And another student commented: “This class has definitely influenced[,] but I believe I had these feelings before taking this class. I am a fairly open minded person. I have recently read Zen and the Art of Mortorcycle [sic] Maintenance and have been influenced by this book also. This course helped by putting words to feelings I had.” This comment is what in part I feel redefinition and its articulation in the classroom can do: help put words to feelings students have.

However, while many answers read very positively about course material, a few answers did not. For example, one student wrote: “No. I was wondering where a lot of information was coming from. Seemed to be a pre-set mind frame with uncontextual [sic] examples.” Another stated: “No, sadly I found it hard to understand the above concepts, [;] I feel they were presented hastily and lacked real-life examples.” And a third stated: “Not really. I already had my opinions formed[,] and I don’t just believe what people tell me. I think the tendency in college is for young people to be influenced by professor’s [sic] beliefs, but I try to maintain my own ideas.”

18. *From the information discussed in this course, do you feel more positive about having artistic or content-driven aspects to your personality (if you feel you are predominantly scientific*

*and form-driven) or more negative or the same?*²³ I categorized the answers as follows: 24 students stated the same, always felt this way, about the same or related answers; 23 stated more positive or related answers or a derivation of more positive; 5 gave answers I categorized as “other”; 3 did not answer. And no one stated that he or she felt more negative.

For example, in response to the this question concerning the effect of course material, a Chemistry major wrote: “I feel like encouraging my artistic side, and trying to meld form and content to make both sides richer.” Someone else wrote: “It has given me validation for having an artistic side to me, which is rare at this school. I now feel that if I had an artistic side it would be a positive thing[.]” And a Computer Science major commented: “I feel this class reinforces the need to enjoy and cherish both aspects of your personality. The person you are has both of these sides even if you try to ignore one of them.” Another student major wrote: “More positive, it seems less obscure and more necessary.” A Mechanical Engineering major wrote: “I feel more confident that I have both in my personality.” Another student commented: “Yes. Especially going to a highly concentrated, form-driven environment, more content-driven people, like myself, feel somewhat outcasted.” And another Mechanical Engineering major wrote: “I feel about the same, but once again, it served as a very enlightening reinforcement.” A Technical Communication major wrote: “Slightly more positive. The things we have learned in this course are very interesting and have provided me with some new ideas.” Another student stated: “I feel really glad to be expanding on my awareness of the different ways our world is composed of.” A Chemical Engineering major stated: “Yes because it opens up my veiws [sic] to the world around me.” A Physics major stated: “Yes, because I feel more well-rounded and more culturally knowledgable [sic].” And another student wrote: “I feel more imbodyied [sic],[;] being aware of this duality makes me full of energy,[.]”

19. *From the information discussed in this course, do you feel more positive about having scientific or form-driven aspects to your personality (if you feel you are predominantly artistic or content-driven) or more negative or the same?*²⁴ I categorized the answers as follows: 28 students answered same, always felt this way, about same or related answers; 11 did not answer;

²³ Fifty-two (52) students answered this question; only 3 of the 55 surveyed did not. Thus, almost everyone answered, not just the students who consider themselves predominantly scientific. Again, this shows student desire to want to express how they felt about the question, as only the ones who stated they were predominantly scientific were asked to answer.

²⁴ Forty-four (44) students answered this question. Again, this means several students answered who do not consider themselves predominantly artistic, showing, I believe, a desire to want to express how they felt about the question, as only the ones who considered themselves predominantly artistic were asked to answer.

9 gave answers I categorized as “other”; 6 stated more positive or similar wording in derivations of more positive, and one (1) stated he or she felt more negative.

One student commented: “I feel better about the scientific aspects. I feel that I am really neither one or the other, but am a synthesis of art and science. This is why I am going into game development.” A Mechanical Engineering major wrote: “Yes[.] Because it is where I have the most room to grow right now. Eventually, I hope to have artistic & scientific growth as the same rate.” Another Mechanical Engineering major drew an arrow to his or her answer to Question 18, showing this was to be the same answer for Question 19. This answer was: “I feel more confident that I have both in my personality.” And another Mechanical Engineering major wrote: “I know how important following a method is[,] but I very much like being artistic and using a more creative approach to things.”

Additional revealing findings. Because this was an open-ended survey, the answers revealed information that had not been specifically requested. These revealing findings are as follows:

**While 2 students articulated that science “saves lives,” no one stated art as doing so.*

When asked, “Do you think one “culture” is more important than the other?”,²⁵ a Biology major wrote: “As a scientist, I do feel that science is more important. Science helps the whole world progress and discover and learn and in its spare time, it saves lives.” Another major commented: “While we need both, the scientific culture keeps things moving, working and on-time. Humanity could survive quite a while w/o much innovation or art, but it would be rather awful.” And another student wrote: “Yes, Science. Without art we wouldn’t have art. Without science we wouldn’t have computers, electricity, indoor plumbing, houses, life.”

**Students expressed science as being beneficial on a large scale, but not as destructive on an equally large scale, or even as destructive at all.* However, there were no questions that directly addressed science and technology as having a destructive aspect. The second student who stated science “saves lives” did recognize the reality of its destructive potential by writing: “You could argue [sic] that: Science saves lives (although/ it probably takes [sic] just as many) & Art helps make life enjoyable & enhances our experience [sic].”²⁶

**Aversion to the arts was only hinted at in approximately three comments. For*

²⁵ In answer to Question 12.

²⁶ In answer to Question 12.

example, one student stated: “No, I think a scientific culture without an artistic would be of more benefit to a functioning society.”²⁷ Another stated that he or she sees the cultures as: “Complementary, as long as artists don’t get delusions of scientific grandeur.”²⁸

To summarize, science, mathematics, engineering, and technology majors surveyed do not readily think of the word “creativity” or “artistic” as part of the definition of “scientific,” even though just over half consider themselves predominantly artistic or both scientific and artistic or both but more artistic. They see themselves as balanced individuals in a society that is not balanced or is in opposition with itself. In other words, they embrace both the scientific and artistic aspects of themselves while living in a certainly fractured and possibly schizophrenic society and educational system that teaches them that these aspects are opposed. While home and social life seem to encourage artistic ideas about self and society, the educational system promotes the sciences as more valid. As a Mechanical Engineering student stated: “School, it seems education (at least when I grew up) was more focused on math and science, and art was just a fun activity on the side.”²⁹ An Electrical Engineering major answered: “I learned these ideas from the school I went to, my community, and my parents. In general, scientific aspects of a person were hyped up a lot in my life and were portrayed as the only way to go.”³⁰ One student commented: “I have always loved science; however, after coming to college, I feel that it has been pounded into my head that science is better and dominant. Our society feels that way[,] too. If someone had to choose between healthcare and a painting. . .logically they will choose science.”³¹ Another student stated that the source of our ideas about the “two cultures” comes: “From books and classes. The ideas are perpetuated that scientists are better and arts people are dramatic.”³²

One of the most consequential findings of the survey, I feel, is *the emphasis of student answers on the importance of science to life and well-being in a practical sense; whereas, the role of art in society is not seen similarly. Nor is there an articulation of the dangers of science on a grand scale and the, albeit arguable, lack of harmful effects of art—visual art, literature,*

²⁷ In answer to Question 11.

²⁸ In answer to Question 10.

²⁹ In answer to Question 15.

³⁰ In answer to Question 15.

³¹ In answer to Question 15.

³² In answer to Question 15.

music, and performance—on an equal scale. Such thinking could lead to the erroneous idea that science is essential to survival while art (thus creativity and innovation) is not essential to survival. In answer to Question 16, concerning where ideas have been developed and perpetuated, one student commented: “...Artists are typically portrayed as free-spirited and creative. Not concerned with society but very emotional.”³³ Considering that literary, visual, musical, and performance artists, especially since Romanticism and certainly in the Modern Era and on into contemporary times, have risked their lives, their freedom, their careers, their ties with country and family, and their sanity to challenge political systems, hegemony, and to address social issues, the human condition, and various manifestations of oppression and suppression, it is disconcerting that students’ definitions and answers—whether personal views or their perception of society—did not reflect that understanding of what it means to be artistic or of the effect of art on society or of the artistic “culture.” It is likely that, before attending college, students have already a firm idea about the arts and artists based on the training by education and by society and on the lack of creative classes required or available. Possibly, humanities courses in primary and secondary education as well as in higher education are not addressing thoroughly this important aspect of the arts. If students even take one art course in their entire secondary or higher education career, which many do not, could students be exposed to art and art history courses that, for example, are focusing more on the aesthetic value of the art than on its socio-political impact? Could history and literature courses not be giving enough attention to the impact of visual, literary, musical and performing art on society? As Peter Selz writes, “It is worth noting that, in fact, nobody has been more aware of the powerful impact of ideas—including works of art—on the economic-political condition than the leaders of totalitarian states” (Selz, 1968, p.456). Literature and modern art, as I tell my students, are about freedom of expression, addressing social issues, articulating and understanding the human condition, and ultimately, they ask their readers and viewers to think. Freedom of expression and thinking is not, of course, what a totalitarian regime wants for the people of its country to have or to do. If this were not true, Hitler would not have made war on literature or on modern art. Yet, going unnoticed in the understanding of what it means to be artistic by science and

³³ The entire answer is: “Same as above [partial answer for Question 15: They were developed in the classroom and perpetuated everywhere!]. Artists are typically portrayed as free-spirited and creative. Not concerned with society but very emotional.” This student answered Question 15 as follows: “They were developed in the classroom and perpetuated everywhere! Math and science are based on facts. You see the stereotypical ‘smart’ scientists with lab coats and calculators always solving problems.”

mathematics students are the social and political issues addressed by countless visual artists, photographers, poets, authors, playwrights, composers, and performers and the changes made by their works, and by art therapy, music therapy, and creative writing or writing therapy. Course instruction can help instill this understanding. A Biology major wrote: “I do not have ties to many artists,[] this class is pretty much where I have developed my ideas. I have definitely seen the impact art can have on a society and the incredible drive of artists.”³⁴ Humanities courses may need more focus on visual art, literature, music, and performance as catalysts for solving problems and artists as the technicians of social change.

In conclusion, based on the results of this survey, I suggest the following areas of deliberation by educators and administrators, if this is not already being done:

*Arts and Humanities mission statements include wording that an objective of the study of visual art, literature, music, and performance is to better understand the world, to help solve problems, and to pursue equality through the study and articulation of the freedom of expression and critical thinking, through the concern for social issues, and through the development of creative thinking and skills;

*Arts and Humanities courses address the arts as methods that can be transformative, and even life saving, and that artists are often technicians of social change;

*Science, Engineering, Mathematics, and Technology departmental mission statements include wording about honoring or fostering the development of the artistic or creative aspects of the discipline;

*Science, Engineering, Mathematics, and Technology courses address the powerful and dramatic impact that technology has had and can have on a society and globally in both creative and destructive ways;

*Complementary or non-oppositional dualism be taught as a philosophical approach to society and personalities;

*Practical or applied visual arts, music, performance, and creative writing courses be required beyond elementary education with the understanding that these artistic and creative skills are applicable and even necessary for the scientific career. To encourage creativity in higher education, performance and creative credits should count as credit toward general degree requirements.

³⁴ In answer to Question 16.

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Disclaimer: In this paper, I have provided selected student comments from a 19-question survey; however, I derived my interpretation from thorough review of all student answers. While this is a qualitative survey and the written comments provide information that mere numbers do not give, I believe quantifying the information from the responses is essential. Quantifying written answers is difficult as wording varies; thus, I have checked and re-checked these answers. However, another reader may interpret an answer somewhat differently than I have. Thus, there is a chance of marginal discrepancy in numbers.

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